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Invention: MOBILE TELEPHONY

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MOBILE TELEPHONY

This invention relates to mobile telephony, and in particular to systems for use on board vehicles.

There has been considerable activity in recent years in proposals to allow the use of mobile telephones in environments where conventional cellular telephony base stations cannot provide coverage, in particular on board ships and aircraft. These vehicles frequently travel beyond the range of land-based cellular base stations, which typically have a range of the order of 1 to 10km.

There are also circumstances when temporary provision of cellular telephone facilities is required at a remote location where such facilities are not normally available, or are temporarily unavailable, for example when the fixed infrastructure has been damaged by a natural disaster.

There are a number of special difficulties to be addressed if a standard cellular telephone is to be used in an aircraft. Firstly, many cellular base stations have antennas arranged for maximum gain in the horizontal plane, so an airborne cellular telephone may not be able to obtain a signal from any base station, even when flying over land served by a cellular base station network. If the range of the base stations does extend to the normal flying height of aircraft, frequency re-use patterns, which allow several base stations to use the same radio frequencies without interference, are designed on the assumption that a mobile unit served by one base station is not able to exchange radio signals with other base stations using the same frequency. This assumption ceases to be valid if a mobile unit is several thousand metres above the ground, since it may be in line-of-sight of a large number of base stations simultaneously. Moreover, although reliable handover of a mobile unit can be achieved from moving vehicles travelling at speeds of up to 200km/h, a typical passenger aircraft travels at speeds approaching 1000 km/h. Airlines also impose restrictions on the use of powerful radio signals on board, as a precaution against possible interference with the aircraft's electronic systems.

For truly global coverage, satellite telephones are available. However, these are expensive and much heavier than a cellular telephone. Both cellular telephones and satellite telephones also suffer from the screening effect of being inside a metal

hulled vehicle. As with cellular telephones, the unrestricted use of a portable satellite telephone within an aircraft may be prohibited.

A user without his own satellite telephone may use special facilities provided on board, such as the service provided to several airlines by the applicant company under the Registered Trade Mark "Skyphone". This uses onboard terminals connected, through a satellite link between the aircraft and a satellite ground station, to the telephone network. Another system, TFTS (terrestrial flight telephony system, marketed as "Jetphone"), operates in a similar manner, but uses a direct link between the aircraft and the ground station, without a satellite link. Similar systems are provided on board ships. However payment for these services is generally at the point of use (or prepaid), and may be in a foreign currency. Calls made to the user's cellular telephone will not be successful unless the calls can be diverted to the telephone number of the onboard user terminal (which will generally not be known to the caller), and any special facilities offered by the user's cellular network will in general be unavailable. A user with his own cellular telephone account which, through "roaming" agreements between network operators, can be used in many different countries, would therefore prefer to continue to use his cellular telephone subscription when travelling within or between these countries on board an aircraft or other vehicle.

Proposals have also been made to allow a user to use his own cellular radio identity when using the satellite facility, instead of a special identity under the satellite system. This would allow billing to be made through the user's normal cellular radio account. A system of this general kind is disclosed in European Patent Application 0915577 (Rohde & Schwartz). An onboard base station can be integrated with other onboard systems, allowing local control of the base station's transmitter, and those of the mobile units with which it is co-operating, so as to keep their power within permitted limits. However, the cellular telephone is not directly connected to the cellular network, so conventional cellular radio location update processes cannot be used to inform the user's home network of its current location and allow incoming calls to be routed to the telephone.

According to a first aspect of the invention, there is provided apparatus for providing telephone connection between one or more cellular radio telephones and a fixed cellular radio switching system, comprising a moveable cellular system, a fixed

cellular radio switching system, and a tracking radio link providing radio connection between the moveable cellular switching system and the fixed cellular switching system, the moveable cellular system comprising a moveable telephone switching system connected to one or more base transceiver stations for providing radio connection with the cellular radio telephones, and having means for initiating a control call over the tracking radio link to the fixed cellular radio switching system in response to the detection of the presence of a cellular radio telephone in the area of coverage of the moveable cellular switching system, and the fixed cellular radio switching system having registration means responsive to such control calls to indicate to other switching systems that calls to a cellular radio telephone currently served by the moveable switching system should be initially directed to the fixed cellular radio switching system, the fixed cellular radio switching system also having call diversion means responsive to such control calls to allow incoming calls directed to the cellular radio telephone to be diverted to the moveable cellular switching system by way of the tracking radio link.

Effectively, the moveable switching system provides a cell, or small network of cells, which moves with the vehicle or other platform on which it is located, but whose operation appears to the user as an ordinary fixed base station of the fixed "host" cellular network to which the tracking network is connected. The fixed network also interfaces with the public switched telephone network (PSTN), and other networks to which it is connected, in a conventional manner. The host network co-operates with the moving cell through the tracking network, but no other cellular network needs modification. In particular, the user's home network requires no special features, so the facility can be used by any subscriber to a cellular telephone having a "roaming" agreement with the host network.

A second aspect of the invention, forming the fixed (ground-based) part of the system, comprises a cellular radio system having a fixed switching system for providing telephone connections for one or more cellular radio telephones, and a tracking radio link for connecting a moveable cellular switching system to the fixed cellular radio switching system, comprising registration means for responding to a control call made by a cellular radio telephone over the tracking radio link to the fixed cellular radio switching system to indicate to other switching systems that calls to a cellular radio telephone currently in the area of coverage of the moveable switching

system should be initially directed to the fixed cellular radio switching system, and diversion means to cause such incoming calls to be diverted to the moveable cellular switching system by way of the tracking radio link.

A third aspect of the invention, forming the moveable (on board) part of the system, provides apparatus for providing telephone connection between one or more cellular radio telephones and a fixed cellular radio switching system, the apparatus comprising a moveable cellular radio switching system for providing a radio connection with the cellular radio telephones, and a tracking radio link for providing radio connection between the moveable cellular system and a fixed cellular radio switching system, wherein the moveable cellular switching system has means for initiating a call over the tracking radio link to the fixed cellular radio switching system in response to the detection of the presence of a cellular radio telephone in the area of coverage of the moveable cellular switching system, means for transmitting data relating to the cellular radio telephone to the fixed cellular radio switching system, and means to receive calls directed to the cellular radio telephone by way of the tracking radio link and route them to the moveable cellular switching system.

According to a fourth aspect, there is provided a method for providing network location functions in a fixed cellular radio switching system for one or more cellular radio telephones when said telephones are in communication with a moveable cellular radio switching system connected to the fixed cellular switching system by a tracking radio link, wherein the moveable cellular radio switching system initiates a call over the tracking radio link to the fixed cellular radio switching system in response to the detection of the presence of a cellular radio telephone in the area of coverage of the moveable switching system, and the moveable switching system and the fixed cellular radio switching system co-operate to cause calls directed to the cellular radio telephone to be transmitted to the moveable cellular switching system by way of the tracking radio link.

The invention further provides a method for routing calls made to a cellular radio telephone currently connected to a moveable cellular radio switching system wherein a fixed cellular radio switching system indicates that the cellular radio telephone is currently connected thereto such that calls are initially directed to the fixed cellular switching system, and wherein such calls, when received by the fixed cellular radio system, are diverted by the fixed cellular radio system to a node in a

tracking radio system, the node in the tracking radio system being associated with the moveable cellular radio telephone switching system, the node then routing the call to the cellular radio telephone by means of the moveable cellular radio switching system.

The node typically has an address similar to those provided for at-seat telephone handsets on aircraft, but not assigned to such a handset. Instead, it is assignable to an individual cellular handset identity when such a handset registers its presence with the moveable cellular switching system.

Preferably the movable system has means for generating an association between an identity code of a destination node of the tracking radio link and an identity code of a celiular radio telephone, and means for storing the said associated identities in stores associated with the fixed and moveable cellular switching systems, thereby allowing both cellular radio switching systems to translate between the cellular radio identity and the node identity.

Preferably the apparatus is arranged such that calls directed to a cellular telephone currently associated with the moveable switching cellular system are diverted to a node of the tracking radio system having the identity associated with the cellular network identity, the node having means for connecting the call to the moveable cellular switching system and the moveable switching system having means for retrieving the cellular network identity associated with the node and routing the call to the cellular telephone having that identity.

Preferably calls directed to a cellular telephone currently associated with the moveable switching cellular system are diverted to a node of the tracking system having an identity associated with the cellular network identity, the node connects the call to the moveable cellular switching system and the moveable switching system retrieves the cellular network identity associated with the node and routes the call to the cellular telephone having that identity.

Preferably the tracking radio link is a satellite link, that is a radio connection between the moving vehicle and a fixed satellite ground station, which connection is routed by way of a relay station in orbit around the earth. The "footprint" of an individual geostationary satellite such as those in the "Inmarsat" system is very large, so an aircraft or ship would usually be able to remain in contact with the same satellite ground station, through one satellite, for the entire duration of a flight or

voyage. However, their "footprints" overlap to a sufficient extent that, should a transfer from one satellite to another nevertheless become necessary, it can be arranged to take place when the system is already shut down. Such shut downs may be required from time to time, for example at safety-critical parts of a flight or when interference from external base stations is likely, or may be arranged for a time such as early in the morning when few people would want to use the service and it may in any case be desirable to discourage the use of telephones to avoid disturbance to other passengers. However, if continuous coverage is required, means may be provided for maintaining a call in progress when such a change is made.

In the described embodiment, which follows the system architecture of the "GSM" standard, an onboard MSC is provided, connected through the tracking system to a ground-based fixed MSC. This arrangement allows integration with other onboard communications systems such as an on-board private exchange. Among other advantages, this arrangement allows emergency calls to be intercepted and handled on board, whereas if all the switching were land-based, emergency calls from mobile units on board would have to be barred, to prevent them being routed to the emergency services local to the fixed MSC, which may be many thousands of kilometres from the moveable MSC.

If the aircraft or other vehicle comes within range of the radio base stations of a conventional cellular radio network there is a risk of interference between the onboard radio base station and those on the ground. To avoid this, the onboard base station's power levels can be arranged to be kept within strict limits, and to impose power level controls on the mobile units. However, ground-based base stations do not have these constraints, which could result in the mobile units on board experiencing interference from the ground-based base stations. This is most likely to occur on an aircraft when it is near the ground. Moreover, the aircraft's operators would not normally have a licence to operate a cellular radio system within the territory being visited, in competition with the resident network. It is therefore desirable that the onboard system be disconnected in such circumstances, either manually, or when such interference is detected, or in response to some other function such as deployment of the aircraft undercarriage or in response to the "weight on wheels" detector which indicates to the aircrew that the aircraft is not

airborne. Disconnection may be achieved by closing down the satellite link, or by disabling part of the onboard system.

The act of disconnection may be used to modify the diversion instructions in the "host" network, to prevent unnecessary signalling over the satellite link.

Once the users have left the aircraft, they would again be able to use their telephones, by "roaming" to the resident network.

Embodiments of the invention will now be described with reference to the Figures, in which:

Figures 1 and 2 show the general arrangement of the various components which co-operate in an embodiment of the invention: Figure 1 shows the moveable vehicle-borne parts and Figure 2 the fixed, ground based, parts.

Figure 3 is a schematic diagram showing the functional relationships between the components of the fixed part of the fixed telecommunications system which co-operate in the invention,

Figures 4 and 5 show the method of operation of this embodiment

Figure 6 is a flow chart showing the process by which the moveable network restores the original settings for a telephone when it disconnects from the first network.

Figure 7 illustrates the forwarding process implemented to a data message.

Figure 8 illustrates a conditional forwarding process for a data message.

Figure 9 is a flow chart showing a call diversion process, for use when the moveable system is temporarily shut down.

The following embodiment illustrates the invention using a standard switched cellular network, and using the terminology of the "GSM" standard. However, the invention is applicable to other cellular networks, including packet networks which are used to carry data over a distributed computer network such as the "Internet", carrying messages using formats such as the "Internet Protocol" (IP). Thus, unless the context clearly demands otherwise, any reference in this specification to switching includes the equivalent routing functions in a packet network of this kind.

The system can be categorised into two main components: namely the onboard part 101 (Figure 1) and the fixed part 102 (Figure 2), which communicate with each other through a satellite connection 6. The onboard part (Figure 1) comprises a moveable cellular system 111,112,114,116 and the onboard part 113 of

the tracking radio system. The fixed part 102 (Figure 2) is itself in two parts, namely a satellite ground station 4, and the fixed "host" cellular network 104, which is a public land mobile network (PLMN) 104, in turn interconnected with other PLMNs 70 and conventional wired networks (PSTN) 8 to allow calls to be made between users of different networks.

As shown in Figure 1, the system provides a cellular radio subscriber with the ability to use his own handset 110 aboard an aircraft, located anywhere within an agreed satellite coverage area. The coverage on board the aircraft can be provided by any suitable means, using known radio repeater distribution systems 111 to provide radio coverage wherever required.

The distribution system 111 is fed by a base transceiver site 112, served by a base site controller 114 and a mobile switching centre 116, which may have its own visitor location register 117, for onward transmission to the satellite ground station 4 via a satellite tracking system 113. The satellite tracking system may be a conventional satellite telephone system as commonly used for ship-to-shore communications, and for the airborne systems previously referred to, providing a satellite link 6 from the aircraft or ship's satellite tracking system 113 to the satellite ground station 4. The satellite ground station 4 is in turn connected to the mobile switching centre (MSC) 141 of a conventional cellular telephone system, referred to hereinafter as the "host" system 104 and shown in Figure 2.

The satellite link 4 – 6 - 113 is therefore between the onboard MSC 116 and an MSC 141 (the "host" MSC) of the land-fixed "host" network 104. The user record in the Home Location Register (HLR) 171 identifies the mobile unit 110 as currently served by the land-based network 104, and routes the call to the host MSC 141, which will in turn recognise from its entry in its land based VLR 144 that this mobile unit is currently being served by the onboard MSC 116. The way this is arranged will be described later.

This arrangement allows integration of the onboard MSC 116 with the onboard switching capability associated with the conventional satellite telephone system and the aircraft's internal communications system 115. In particular it provides a simple means of providing passengers and crew with a "Wireless PBX" facility, as users on board the aircraft can communicate with each other through the BSC 114 without using the satellite link 4 - 6 - 113. When a call is made by a cellular

telephone 110, the onboard MSC 116 first consults its VLR 117 to establish whether the called party is currently served by the same MSC 116. If this is the case, it connects the call without the use of any inter-MSC links. Thus calls made between two users both on board the aircraft 101 may be made without the use of the satellite link 4 – 6 – 113. The satellite connection provides several voice channels and a signalling channel (supervisory control – management channel), and can be made by any connection of appropriate capacity.

The host network 104 may support one or more further base site controllers 142 controlling conventional base transceiver sites. The host Mobile Switching Centre 141 also has an associated "Visitor Location Register" 144 which, in conventional manner, records details of the cellular telephones currently co-operating with the Mobile Switching Centre 141, so that details can be exchanged with the Home Location Register 73 of the user's home network for billing purposes, and to allow incoming calls to be routed correctly. These details include the identity of the link 4, 142 to which the user is connected, allowing different call charges to be applied for use in different cells, and in particular to distinguish between calls made through the onboard base transceiver site 112 and calls made through conventional base site controllers 142 .

In the cellular mobile network 104, standard GSM functionality is used. Users aboard the aircraft will be able to use this service provided they are subscribers to the host network 104, or any other network 70 which has a "roaming" agreement with the host network 104, provided the subscriber has the roaming capability authorised by his service provider.

In this embodiment of the invention, the "host" network 104 operates like a conventional cellular network, but is provided with an interface unit 148 for interworking with the satellite ground station 4. This interface 148 allows the switching centre 141 to obtain user details (in particular the identity of a mobile handset) from the satellite system 4 to allow it to appear to the network 104, and thus to the HLR 73 in the user's home network, that the mobile handset is in radio communication with a base station under the control of the mobile switching centre 141 when in fact it is in communication with the onboard MSC 116. The mobile switching centre can then arrange for call forwarding instructions to be stored in the VLR 144, to cause incoming calls directed to that handset to be diverted, through the

switching system 40 of the satellite network 4 (to be described later), to the onboard MSC 116.

The satellite ground station 4 shown in Figure 3 has a radio antenna system 44 for communicating with the onboard system 101, through a satellite link 6 or otherwise. Signals are handled by an Access Control Signalling Equipment (ACSE) 40 which carries out switching functions to route calls to or from the public switched telephone network (PSTN) 8.

The aircraft may have an at seat information system 200 with provision for connection of the handset 110, similar to the hands-free arrangements commonly provided in cars. This allows audio signals to be transferred to the at-seat system's headset 202, preventing disturbance to other passengers. The at-seat system may also have means for collecting ringing tone from the handset 110, and generating a visual alert on the display screen 201 or an audible one on the headset 202, again avoiding disturbance to other passengers. As with car-based systems, the connection may also provide facilities for charging the batteries of the handset. This would encourage passengers to connect the handset.

The operation of the system will now be described with reference to Figure 4. When a mobile unit 10 first makes contact with the onboard cellular system 101 it transmits its identity code (IMSI) to the onboard MSC 116 in the usual way. The onboard MSC 116 can obtain verification data from the user's HLR 73 (identified by the IMSI code) to verify the authenticity of the user, and permit outgoing calls. However, because the onboard MSC 116 is only contactable through the satellite system 4, incoming calls to the mobile unit 110 cannot be reliably routed to the onboard MSC 116 over a conventional link. In order to avoid a requirement for special facilities in each network 70 it is convenient to make the mobile unit 110 appear to be working to a conventional mobile switching centre 141.

When the onboard MSC 116 detects a call attempt or registration attempt from a mobile unit 110, (step 1601) it collects from the mobile unit its identity code (IMSI) and passes it to a processor 118. If the processor 118 has not previously done so, it generates a temporary onboard identity for association with the mobile identity code (IMSI), and stores it in a memory 119 (step 1602). For aircraft fitted with at-seat satellite telephone equipment, each handset has an identity code (generally related to the number of the passenger seat to which the handset is fitted) to allow

outgoing calls to be billed to the correct user and to allow the system to be used to communicate between passengers. Spare numbers in this system (referred to herein as "pseudo seat numbers" - PSN) may be used as the temporary onboard identities allocated to mobile handsets working to the onboard MSC 116. If the mobile handset 110 has previously contacted the onboard MSC 116, and not subsequently de-registered, the processor 118 retrieves the PSN corresponding to the IMSI from the memory 119 (step 1603).

In existing onboard systems a user cannot receive calls unless the caller knows the unique "AES" number of the at-seat terminal 201, which is made up of the seat code and an identity code of the aircraft (which together make up a unique "AES" code). It is unlikely, even for a normal satellite handset, that a caller would know the AES code, as the number depends on the identity of the aircraft, the seat, and the serving satellite or base station. (It should be noted that the passenger list of an aircraft is not normally released to the general public until the flight has ended, for security reasons). The present embodiment allows the host network to translate the called party's IMSI to an AES code (including seat number), which includes a pseudo-seat number (PSN), which is allocated randomly from the numbers left spare after codes have been allocated for at-seat terminals. The translation takes place in the host network, without the need for the caller to know the AES code.

The temporary onboard identity code PSN associated with the called party's IMSI is returned to the onboard MSC 116 which sets up a call over the satellite system to the host MSC 141 of the host network 104 (step 1604). For a normal satellite call, the satellite system requires certain authentication data on call set up, namely the AES code and a subscriber identity code which normally identifies an individual subscriber to the satellite system or, if the user does not have an account with the satellite system, credit card details or other details to allow payment to be made. In the present case the onboard MSC 116 provides the cellular telephone's code (IMSI) as the subscriber identity code. For security reasons, this code may be encrypted. If an outgoing call attempt is being made, a call attempt is then made to the number dialled; otherwise a special code, referred to herein as the non-call code ("NCC") is used.

A subscriber management system 42 in the satellite ground station comprises a data acquisition unit 47 which reads identification data transmitted from

the aircraft (step 1605) to identify the subscriber, confirm his account details and arrange billing for any calls made, through a billing system 45 which raises invoices, or interacts with the systems of a credit card operator, bank, or other telephone operator. In the present case the card management system recognises the IMSI transmitted as the subscriber identity. Provided the IMSI has previously been registered with the subscriber management system 42 (as will shortly be described: step 1616) the call is authorised using the satellite system's authorisation checking and billing system as for any call from an onboard satellite terminal, and connected to the PSTN 8 (step 1606), billing details being passed to the home network through the host MSC 141.

If the caller has not previously been registered, but a special non-call registration code is used, the ACSE 40 recognises it as being an authorised free call to the host MSC 141 and processes it accordingly (step 1607) by retrieving the data and forwarding it to the interface unit 52 in the host network 5 . Calls using this code are permitted by the subscriber management system 42 even if the IMSI has not previously been registered with it.

The host network 104 will, in general, not be the same as the user's home network 70. In the host network an interface unit 148 provides certain additional functionality to co-operate with the satellite ground station 4.

When a call is received by the satellite ground station 4 using the non-call code (NCC) the ACSE 40 retrieves the data and passes it to the interface unit 148 (step 1608). The interface unit 148 then retrieves the identity (IMSI) of the cellular telephone, and the AES identity of the onboard terminal 201 (step 1608, Figure 4). The IMSI (de-encrypted if necessary), is passed to a network registration unit 145 which exchanges signals with the host mobile switching centre 141 in the same way that a real cellular telephone would do if registering through one of its base stations 74. The mobile switching centre therefore informs the user's Home Location Register 73 that the mobile telephone is now registered with the network 104 (step 1611). The Home Location Register 73 records that the mobile handset is now registered with host MSC 141 (step 1612).

It should be noted that, although registered with the host MSC 141, the user's mobile handset is not operatively connected to the host MSC 141. The user,

and the handset, may be on a suitably equipped vehicle anywhere in the world within the coverage area of the satellite network 6.

The user's details, including any diversion instructions, are next sent by the Home Location Register 73 to the host network's VLR 144 (step 1613). A store 147 records a copy of the details of these diversion instructions (step 1614), for subsequent retrieval when the mobile unit deregisters.

Conventionally, any incoming calls for a mobile user are sent in the first instance to the user's home network 70, and the HLR 73 provides information to identify the MSC where the mobile handset is expected to be found, which is the host MSC 141. Consequently, in the present arrangement, any incoming calls intended for the mobile user will now be directed to the network 104, as the mobile user is currently registered there.

The interface unit 148 passes the AES code to a call diversion instruction unit 46, which generates a "divert on busy" instruction to the VLR 144 (step 1615). This is a standard divert arrangement, and operates such that should the mobile unit appear to be already engaged on a call when a new call attempt is made to it, the new call attempt is diverted to a specified directory number, in this case the AES code allocated to the mobile unit. This diversion instruction replaces any previous instruction held in the VLR 144.

Finally, the registration process is closed by returning an authorisation code from the host MSC 141 to the subscriber management system 42 (step 1616) to allow the IMSI to be recognised as a valid user identification for subsequent outgoing calls.

Of course, although the mobile telephone 10 is recorded in the home location register 73 and in the host's visitor location register 144 as being connected to the host MSC 141, it is not really there and therefore the host MSC 141 is unable to connect incoming calls to the mobile telephone in the conventional way, or to identify the current true operating condition (switched off, busy, ready for calls, etc) of the mobile handset 110. Instead, the system responds to a call attempt as will now be described with reference to Figure 5.

When a call attempt is made (step 1701), the MSC in the home network 70 to which the call is initially routed obtains from the HLR 73 the current location of the mobile telephone (step 1702), and on receiving the identity of the host MSC 141,

directs the call there (step 1703). The host MSC 141 in turn attempts to transmit the call attempt to the currently serving base station, which is in fact the interface unit 148 (step 1704). If the disconnect procedure already described with reference to Figure 8) has been carried out, the call will not be connected (step 1705) and a signal is transmitted back to the home MSC 70. Otherwise, the interface unit 148 automatically returns a "busy" signal to any such request (step 1706). Note that the interface unit 148 has no information regarding the true operating state of the mobile unit 110. It is merely arranged to emulate the target mobile unit's response to a call attempt when the target mobile unit is in the "busy" condition.

The host MSC 141, on receiving the "busy" signal, checks whether any incoming call currently in progress to that mobile handset has already been diverted (step 1707). (This is a standard procedure, done to ensure that call diversions are not attempted if they will not actually succeed). If there is no such diverted call in progress, the host MSC 141 retrieves the diversion information (the AES) from the VLR 144 (step 1708) allowing it to route the call through the PSTN 8 and the satellite system 3 to the onboard system 101 (step 1710).

The onboard system 101 routes incoming calls to a node of the onboard system according to the AES code. If the node is connected to a real at-seat terminal, the call is simply routed to that terminal. However, in this case, the code corresponds to a pseudo seat number, which the onboard satellite system switch 113 recognises as meaning that the call is to be routed to a node connected to the onboard MSC 116. The onboard MSC 116 uses the processor 118 to retrieve from the memory 119 the cellular identity (IMSI) corresponding to the PSN, (step 1711) and then connects the call to the mobile handset 110 having that identity in the conventional manner (step 1712). Thus the interaction between the onboard MSC 116 and the handset 110 is entirely conventional: ordinary handsets can be used and no initial authorisation is required other than the standard procedures used to ensure that international "roaming" is permitted.

If a second call attempt is made to a handset already in use, the ACSE 50 will identify that the divert instruction will not work as it is already handling a diverted call to that number. The default condition in such cases is to arrange for the second call to be diverted to the user's voicemail address (not shown) in his home network 70.. The user may also be sent a message to inform him of the new

voicemail message. This message would normally be sent to the mobile unit, which appears to the host MSC 141 to be co-operating with the interface unit 148, so the host MSC 141 transmits the data message to the interface unit 148 (step 1711). In order to inform the user of the new voice mail message, the interface unit 148 now regenerates the data message for forwarding to the onboard MSC 116 via the satellite system 3 (step 1712) for alerting the user terminal 110 either during the call or after it ends.

As the onboard system 101 is itself mobile, being on board an aircraft, call routing to that termination may require revision from time to time. For example, the "Inmarsat" satellite system comprises several geostationary satellites, which each provide cover for part of the earth's surface. These areas of coverage overlap to a large extent, but nevertheless on a long flight the aircraft may pass out of the area covered by one satellite into that served by another. This causes a small but significant change in the network address AES of any terminal on board the aircraft. The aircraft location register 41 monitors the identity of all aircraft currently being handled by each satellite ground station 4. When an aircraft moves into range of a different satellite 6, the call diversion unit 146 responds by transmitting a new call diversion instruction to the VLR 144, so that any further incoming call attempts are diverted to the new network address (AES) of the node corresponding to the terminal 110. Note that the diversion store 147 is not updated.

Note also that this does not affect calls already in progress. There is usually sufficient overlap in satellite coverage areas that handover from one satellite or base station to another can be arranged to take place when no call is in progress

In use, both parties to a call, and most of the cellular network, operate normally. The cellular telephone 110 co-operates with the base station 112 on the aircraft as it would with any other base station 74. The home location register 73 identifies the cellular telephone 110 as currently served by the host MSC 141, and routes incoming calls accordingly. This invention therefore allows connection to be made to conventional handsets 110 using standard cellular telephony equipment. The operation of the host MSC 141 and the onboard MSC 116 are both largely conventional except for the number translation functions carried out by the interface units 118, 148. Using roaming capabilities, just one host MSC 141 can provide

connection to a large number of airborne MSCs 116, anywhere in the range of the satellite system 4, 6.

To allow the use of the at seat display system 201 for data messages, not suitable for transmission over the PSTN and satellite system in their original form the interface unit 148 is provided with a data handling processor 149 for receiving data messages received over a packet data system 9 by way of the MSC 141 and intended for users currently associated with the interface unit 148. These messages include SMS messages sent from other callers, and SMS messages generated by the MSC 141 itself to alert the user that a message has been sent to the voice mail system. The format of such a message is shown in Figure 7, and the process of sending and receiving it is shown in Figure 8.

The original message 900 basically consists of a data payload 901 and an address 902, which is the IMSI of the destination mobile telephone (figure 7a).

When the interface unit 148 receives such a data message (step 990) it retrieves from the data acquisition unit 149 the data network address of the at-seat entertainment terminal 201 corresponding to the user's cellular identity which was originally provided to the data acquisition unit 149 when the user carried out the registration procedure (step 991). The interface unit 148 next generates a data call to that address (step 992), in a form suitable for transmission by the MSC 141 (step 993) over the packet data network 9 to the aircraft, with an address header corresponding to the data network address of the user's at-seat terminal 201. This data call may be a short message to indicate that a message is awaiting delivery, and displaying on the screen 201 an invitation to the user to dial a special code on his handset 110 to accept the message (step 994), and any charge associated with it. This acceptance is transmitted back, by way of the MSC 141 to the interface unit 148 (step 995). (These steps 992 – 995 may be omitted if it is not required for users to acknowledge acceptance before receiving a data message).

The interface unit 148 then replaces the address header (the IMSI) 902 in the original data message with a code 912 identifying the terminal 201 and encapsulates the message in a form suitable for transmission over the packet data network 9 to the aircraft (step (996), with an address header 910 to send it to a data network interface 204 serving the onboard entertainment system 200. It can thus be transmitted to the interface 204 over the packet data network 9 (step 997),

effectively as a packet with an address header 910 and a payload made up of the at-seat terminal number 912 and true payload 901 (Figure 7b).

On receipt of the data message, the on board interface 204 extracts the data message payload 901, 912, (Figure 7c) (step998) and identifies the individual at-seat terminal 201 identified by the address 912. It can then cause display of the data message payload 901 on the screen 201 of the appropriate terminal (step 999).

If password protection is required, for example to ensure that the user is present when the message is displayed, the payload 901, 912 can also include a password code 913, which causes the interface 204 to withhold the remainder of the payload until a predetermined sequence of keystrokes has been entered by the user in the terminal 201.

In this embodiment the invitation (step 992) is sent as a voice message to the user terminal 110, and prompts the user to identify his at-seat terminal (in practice the user will be asked for his seat number), either by key presses (using DTMF coding) or by voice (step 995). The acceptance step is therefore performed over the voice network, rather than the data network. The host MSC 141 uses this information to generate an AES code identifying the user terminal, to be applied to the data message 910 (Figure 7). The host MSC may store this code for use with subsequent data messages, allowing the host MSC 141 to process further data messages without requesting this information from the user again. The request for the user's seat number may instead be made when he first registers his telephone 110 with the onboard MSC 116.

Figure 9 shows a process for intercepting calls when the onboard system 101 is switched off at times when its operation could interfere with conventional land-based cellular systems or with electronic control systems of the vehicle, to enforce "quiet" periods on board, or to allow transfer of the satellite link from one satellite to another. The control to switch the system off may be performed manually or under the control of a sensor detecting interference from nearby radio base stations 74, or an operational condition of the vehicle, such as deployment of the aircraft undercarriage, low altitude, or "weight on wheels", communicated to the onboard system by means of the control data bus 22. When such a disconnection occurs (step 1501), a signal is generated in the onboard system 101 (step 1502) for transmission over the satellite link 6, to the ground station 4 (step 1503). This signal

causes the satellite ground station to invoke a call failure mode for any call directed to the onboard system 101 of the specified vehicle (step 1504).

Any call now diverted by the MSC 141 to a number corresponding to a node on board the vehicle (step 1505) will then receive a "call failed" indication from the ground station (step 1506), without any signalling required over the satellite link 6. Such failed calls will be re-routed according to the user's own diversion instructions, stored by the host MSC 141 for use when the user's handset is busy (step 1507). Generally, such instructions will be to divert the call to a voicemail system in the user's home network. In addition, the host MSC 141 will record the existence, and possibly the origin (Calling line identity – CLI) of any such call attempts (step 1508).

When the onboard system 101 is re-activated (step 1511) a further signal is transmitted by the onboard system (step 1512) for transmission over the satellite link 6 to the ground station 4 (step 1513). This signal causes the satellite ground station to revoke the call failure mode for calls directed to the onboard system 101 of the specified vehicle (step 1514). When a user 110 reconnects to the onboard system 101 (step 1515) the onboard system transmits a signal to the host MSC 141 (step 1516) which causes the host MSC to retrieve the call attempt record previously stored for that user (step 1518). If one or more such call attempts have been made, the MSC returns a message to the user 110 (step 1519), prompting the user to retrieve his messages from the voicemail system should he so wish.

During the flight the user may decide that he no longer wishes to have his calls diverted to the terminal 110, and switches it off. The onboard MSC 116 will therefore fail to locate the mobile handset 110 at the next registration update. As previously discussed, it is also desirable to disable the onboard system 101 when the aircraft is on approach to landing, to avoid interference with aircraft systems at this critical point in the flight (or distractions to passengers in the event of an emergency), and also to avoid interference with base stations on the ground. Disconnect codes may therefore be generated in the onboard MSC 116 for all the handsets 110, either by the cabin crew or automatically in response to a signal detected on the aircraft's data bus 22 which is indicative of the imminent end of the journey, such as time remaining to destination (as determined by the aircraft's flight management system), low altitude, deployment of undercarriage, or weight on wheels.

Generally, the detection of the same IMSI from two sources causes an HLR to disconnect both callers as a fraud prevention measure. Therefore, if the user, having left the aircraft, switches on his telephone 110 before the network 141 has reported a loss of the mobile unit from its own network, the mobile unit may be perceived by the HLR 73 as being registered with two networks at once. To avoid this possibility, a disconnection procedure is followed as described with reference to Figure 6.

On receiving a de-registration signal (steps 801,802 Figure 6), the host network 104 retrieves the original divert information from the store 147 (step 803) and stores that in the VLR 144 (step 804), thereby restoring the user's own selected divert instructions automatically. This ensures no further calls are routed to the onboard terminal 21.

Once he has left the aircraft, the user may switch on his mobile telephone 110, which will register with the local network (e.g. network 70), informing the home location register 73 of the location update (note that in general the HLR 73 will not be in the same network as the local network 70). The HLR 73 retrieves the user's VLR settings from the previous host network 102. Because the original VLR data has been restored (step 804), the temporary divert data used whilst the user was connected to the onboard system is not fed back to the HLR. All data relating to the user can then be deleted from the VLR 44 in the "host" network 102.